

ON FOSSIL LEAVES (OLEACEAE) AND A NEW TYPE OF FOSSIL POLLEN  
GRAIN FROM AUSTRALIAN BROWN COAL DEPOSITS.

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(Communicated by Dr. W. R. Browne.)

(Plates viii-x; four Text-figures.)

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INTRODUCTION.

Mummified leaves, which on structural grounds are believed to have belonged to an extinct member of the family Oleaceae, occur in considerable numbers in the brown coal deposits of the Latrobe Valley in Victoria and Moorlands in South Australia (Cookson, 1946). The evidence to be submitted below suggests a possible affinity with the tribe Oleineae (Knoblauch, 1897), but is insufficient to connect them directly to an individual genus of this tribe. For this reason the generic name *Oleinites*, n. gen., which implies tribal affinities only, is proposed for them.

Two species of *Oleinites* have been discovered. One of these, namely, *O. Willisii*, n. sp., has been collected in some quantity from the upper zones of the open cut at Yallourn and in Bore 28 at 150 feet at Hazelwood, south of Morwell. *O. crenulata*, n. sp., the second species, has been found only in the deposits at Moorlands.

Ettingshausen in 1888 described a fossil leaf from Vegetable Creek in New South Wales to which the name *Olea Macintyreii* was given. His identification, however, was not substantiated by anatomical details. Apart from this doubtful species, I know of no other record of fossil Oleaceae from southern Tertiary rocks.

The fossils typifying *Oleinites* are glossy, transparent, and paper-like in appearance and greenish-brown to amber in colour. Although nothing remains of the original structure but the outer wall of the epidermal cells, the general form of the leaves is faithfully preserved. Frequently the thicker upper cuticle alone is represented, but in more favourable examples useful portions of the lower cuticle have been found. The thickness and high degree of cutinization of the outer walls of the epidermal cells were apparently responsible for the excellent preservation of both morphological and anatomical features.

Usually *O. Willisii* is aggregated into thick, layered masses in the coal (Plate viii, fig. 1), from which individual leaves or pieces of leaves can be readily detached. *O. crenulata*, on the other hand, is more sparsely distributed in the coal and is preserved in a more fragmentary condition. For this reason, *O. Willisii* has been chosen as the type species of the new genus.

Portions of such fossils can be mounted directly either in Canada Balsam or glycerine jelly, but clearer and cleaner preparations have been obtained by bleaching for about fifteen to thirty minutes in a 12% solution of sodium hypochlorite. Treated cuticles, after a thorough washing with water, can then be stained with safranin and mounted in glycerine jelly.

DESCRIPTION OF FOSSILS.

*OLEINITES WILLISII*, n. gen., n. sp.

*External Features.* Plate viii, figs. 1-5.

The leaves are simple, shortly petiolate, and oblanceolate to almost spatulate. They show a considerable variation in size, the examples measured ranging from 1.9 cm. in length and 2 mm.-2.3 cm. in width. They have an obtuse and usually more

or less deeply retuse apex and an entire and strongly thickened margin. Apart from the midrib, which is indicated on both surfaces, the venation is not evident.

*Peltate Hairs.* Plate ix, fig. 8; Plate x, fig. 24.

Trichomes which seem to come into the category of peltate hairs are conspicuous features of both leaf surfaces. Their state of preservation permits the interpretation of their general form, but precludes a clear and positive statement regarding the finer details of structure. Furthermore, it is impossible to say whether these hairs had a glandular function or were more comparable to "clothing hairs" such as occur, for example, in *Olea europaea* (Solereeder, 1908, p. 523). Nevertheless, it should be mentioned here that the frequent occurrence of epiphyllous fungi on such leaf remains might be more compatible with a glandular character. Because of this uncertainty regarding their function they will be referred to subsequently as peltate hairs.

Each peltate hair consisted of a stalk and a radially constructed shield of variable size. The stalk itself is never preserved, but its upper limit is clearly marked by a circular thickening 18–30 $\mu$  in diameter, beneath and in the centre of the shield. Moreover, the fact that it was sunk beneath the general level of the cuticular surface is shown by a small elevation in the vicinity of each hair, which is plainly visible when a cuticular surface is viewed from within (Plate viii, fig. 7). The position of the hairs is indicated by corresponding depressions on the coal when the fossil is removed.

The shield was apparently composed of radiating cylindrical cells with cutinized walls and wide lumina, but the latter are usually preserved in a more or less contracted condition. The number of rays varies from sixteen to thirty-six or possibly even more, according to the size of the shield. In the majority of hairs, the diameter of the shield ranges from 58–106 $\mu$ , the average being approximately 80 $\mu$ . However, considerably larger hairs, the diameter of which is between 119–186 $\mu$ , occur at intervals, particularly on the midrib. In these examples it is difficult to determine with accuracy either the number or arrangement of the cells into which the shield is divided. The ray-cells appear to have been free from one another for the greater portion of their length. This may have been a natural feature, but the possibility that the apparent disunion resulted from *post mortem* changes must also be borne in mind. The length of the individual cell is exceedingly variable and only a few reach the centre of the shield, the majority ending at the margin of the stalk (Text-fig. 3). The appearance of some of the hairs suggests that a second smaller shield composed of small, free ray-cells may have been present on the upper surface of the principal shield.

*Lower Epidermis.* Plate ix, figs. 9–11.

The stomata are restricted to the lower epidermis, where they assume a more or less linear grouping around, and at some distance from, the peltate hairs. The approximate number per sq. mm. is  $100 \pm 40$ . They are oval to circular in surface view, and usually distinctly flattened at the poles. The considerable variation in size of the stomata, which is especially evident in *O. Willisii*, is possibly the most distinctive and reliable diagnostic feature of *Oleinites*. In this species, stomata of three quite arbitrary size groups can be recognized. The majority come within the limits of 29–58 $\mu$  for the axis parallel to the pore (to be subsequently referred to as the length), and 26.6–58 $\mu$  for the axis which crosses the pore (the width), the approximate average for this group being  $46 \times 44\mu$ . Larger stomata, which occur sporadically on the lamina, comprise the second group; they have a range of from 61–85 $\mu \times 53$ –80 $\mu$ , and an average of  $72 \times 69\mu$ . Giant stomata, usually restricted to above or near the midrib, are more sparingly developed. Those observed have measured from 93–119 $\mu$  in length and 53–112 $\mu$  in width.

The outer walls of the guard cells are strongly thickened, and in the larger stomata show clearly defined concentric cuticular striations. The dorsal limits of the guard cells are sharply defined, and the poral rims are pronounced. The epidermal parenchyma can seldom be distinguished, even in otherwise favourable cuticles. With low-powered objectives the outlines of the cells surrounding the hair bases are sometimes visible. These are of moderate size and have thin, deeply sinuous lateral walls. The outer wall is thickened and cutinized, but to a lesser degree than that of the upper epidermis.



The peltate glands conform to the general description already given; they are rather widely spaced, the approximate number per sq. mm. being 9.

*Upper Epidermis.* Plate ix, fig. 8.

This consists of uniform, sinuate parenchyma; the outer cell walls are about  $13\mu$  thick and heavily cutinized. Peltate hairs, similar to those on the lower epidermis, are present, where they average 10 per sq. mm.

#### OLEINITES CRENULATA, n. sp.

*External Features.* Plate x, figs. 16–21.

A complete leaf cuticle of this species has not been seen, but a workable description permitting its identification has been built up by a study of a number of the larger fragments of cuticle.

The leaves of *O. crenulata* seem to have varied considerably in size, for the smallest specimen observed measures 1 cm. in length and 0.5 cm. in width, and the larger, incomplete specimen, illustrated in Plate x, figure 16, is 2.5 cm. long and 1.8 cm. wide. The lamina which appears to have been broadly lanceolate tapers towards the base. In several fragments the apex varies from obtuse to subacute, and is sometimes slightly retuse (Plate x, fig. 17). The margin of the leaf is unthickened, and in the distal region, at least, is slightly crenulate. The venation is prominent on both surfaces; from the midrib strong lateral veins are given off at an angle of about  $75^\circ$ , and these give rise to numerous finer veins which anastomose to form a conspicuous network. This is indicated on the upper surface by irregular, raised areas, each of which is separated by the slightly sunken cuticle covering the venules.

*Lower Epidermis.* Plate x, figs. 25, 26.

The stomata occur only on the lower epidermis, where they are restricted to the areas marked out by the veins. Here they are closely arranged and number about 450 per sq. mm. They are oval to circular in surface view and average  $35\mu \times 32\mu$ , their range in length being 24–50 $\mu$ . Much larger stomata occur infrequently; these vary from 53–106 $\mu$  in length and from 37–101 $\mu$  in width. The dorsal limits of the guard cells are clearly defined and their outer walls are concentrically striated. The poral rims, which are frequently missing, however, do not appear to have been especially thickened.

The cuticle of the stomatal parenchyma is seldom preserved, and in one specimen only have the deeply sinuous outlines of epidermal cells been distinguished (Plate x, fig. 26). The parenchyma appears to have been uniform and the outer walls of the epidermal cells non-striated. The cuticle of the elongated cells covering the veins, however, is longitudinally striated. Peltate hairs of the same general type as those of *O. Willisii* are rather widely spaced in the lower cuticle.

*Upper Epidermis.* Plate x, figs. 23, 24.

The cells of the upper epidermis are large and deeply sinuate; the cuticle shows undulating striations which follow, more or less, the outlines of the cells. Peltate hairs average  $20 \pm 13$  per sq. mm.; their shields have diameters ranging from 53–128 $\mu$  and the number of rays into which they are divided varies from 12 in the smallest to about 36 in the largest examples. The rays lie in one plane, but all do not reach the centre (Plate x, fig. 24).

#### SYSTEMATIC POSITION OF OLEINITES.

The identification of fossil leaves, even when structural features enable comparisons with living types to be made, is often associated with an element of doubt, and such is the case in the present instance. No recent type has been found having a cuticular structure with which that of *Oleinities* can be exactly matched. When, however, individual features of the fossil cuticles are compared with similar characters in recent species, the number of points on which agreement is reached is sufficient strongly to favour, if not definitely to establish, an alliance with the Oleaceae in general and the Oleineae in particular. The facts that support such taxonomy are summarized as follows:

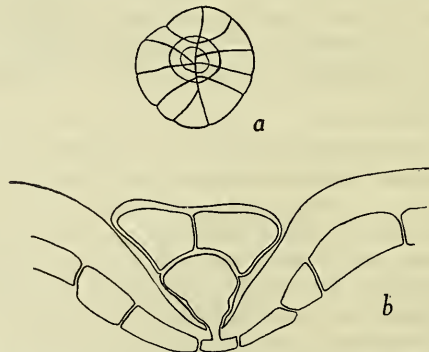
(a). *Size and Shape of Stomata*.—Perhaps the most striking feature of the lower cuticles of *Oleinities*, as exemplified by *O. Willisii* and *O. crenulata*, is the wide range in size shown by the stomata. Furthermore, the development of exceedingly large stomata, which sometimes reach a length of  $119\mu$ , is both obvious and characteristic. It was this unusual feature that originally suggested the Oleaceae as the family to which *Oleinities* might be related. Solereder (loc. cit., p. 522) writes: "It is also worthy of remark that sometimes, e.g. *Forestiera porulosa*, large and small stomata occur side by side." This statement fitted so well with the appearance of *Oleinities* that cuticles of some of the other members of the tribe Oleineae were examined. The figures obtained show that of the recent species examined 65% of the species of *Olea* and 100% of those of *Notelaea* possess a variable number of stomata which are conspicuous on account of their greater size and isolated position. The length of such "large" stomata exceeds the average length of the smaller stomata by from  $5-20\mu$ . Moreover, even when large stomata, as such, are indistinguishable, a variation in length of from  $7-20\mu$  is a natural occurrence in all of the species investigated. In spite of lower maxima and minima, therefore, the range in length is comparable to that of *Oleinities*.

As far as actual size is concerned, the stomata of *Oleinities*, especially *O. Willisii*, appear to be quite unusual. The large stomata of *O. concolor*, for example, which average  $60 \times 40\mu$ , fall far short of the dimensions of the large stomata of *O. Willisii*. The stomata of *O. crenulata*, being smaller, are more comparable with those of recent species, but here again giant stomata far above the average distinguish this species from recent types.

The shape of the stomata in species of *Olea* and *Notelaea*, since it varies from elliptical to circular according to the species, is a less important diagnostic character. In *Oleinities* the stomata are oval to circular in surface view and in this respect approximate to those of *O. acuminata*, *O. maritima*, *O. dioica*, *N. longifolia* and *N. ovata*, in all of which the stomata are roughly circular.

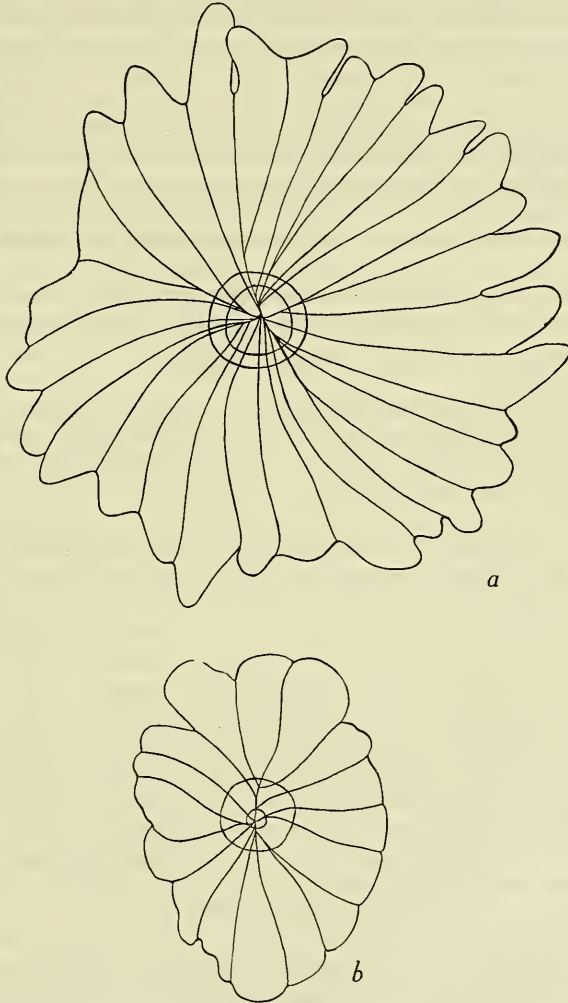
Great variation in the grouping of the stomata has been observed. In the majority of recent species the stomata are more or less evenly distributed but are usually wanting over the veins (in *O. foveolata*, as in *Oleinities Willisii*, large stomata are sparsely developed over the midrib), and in the immediate vicinity of the trichomes and large stomata. Sometimes, e.g., in *O. paniculata* a wider zone around each hair is devoid of stomata, a feature reminiscent of *O. Willisii*. The somewhat linear arrangement of the stomata in this species and in *O. foveolata* is another point of convergence.

(b). *Peltate Trichomes*.—These are present, according to Solereder (loc. cit., p. 521), in all genera of the Oleaceae, but this author does not mention whether they are constantly distributed on both sides of the leaves. During



Text-fig. 1.—(a). Peltate gland of *Olea foveolata* in surface view,  $\times 500$ . (b). Peltate gland of *Olea lanceolata* in vertical section,  $\times 500$ .

the present investigation peltate trichomes have been found invariably on the under epidermis, and with only one exception, namely, *O. foveolata*, on the upper epidermis. Peltate hairs have been recorded in a number of families and genera (Solereder, p. 1121), but in many of these, appear to be restricted to the lower epidermis. Their occurrence on both cuticular surfaces of *Oleinites*, though in itself insufficient evidence of affinity with the Oleaceae, corroborates the assignment to this family.



Text-fig. 2.—Peltate hairs of (a) *Olea europaea* and (b) *Olea paniculata*,  $\times 500$ .

In most recent members of the Oleaceae the trichomes take the form of peltate glands (Prillieux, 1856). In these the head ranges from  $29\text{--}60\mu$ ; it is oval to spherical with usually an entire margin, and is divided into from 8–16 cells. In contrast are the “clothing hairs” of Solereder which distinguish such species of *Olea* as *O. europaea*, *O. chrysophylla* and *O. cuspidata*. In these species the shields, which are divided into 24–30 partially separated cells, are large, the average diameter being about  $160\mu$ ; moreover, they overlap one another so that an effective covering for the leaf-surface is provided. In a few species, e.g., *O. paniculata*, *O. glandulifera* and *O. exasperata*, an intermediate type both as regards size and distribution appears to be distinguishable. The



average diameters of the shields of these species vary from 80–90 $\mu$  and are so spaced that they do not overlap one another; in addition the ray-cells, which number 16–20, are usually completely united. It is not possible to decide from herbarium specimens whether this type is of the nature of small clothing hairs or large peltate glands, so that, for convenience, they will be arbitrarily termed peltate hairs.

As regards the size of the peltate hairs of *Oleinites*, the most remarkable feature, when comparisons with recent species are made, is the extreme difference in size of the shields of the largest and smallest hairs. The large hairs with shields ranging between 100 and 186 $\mu$  come within the range of those of the *O. europaea* class, but the majority have diameters considerably below these figures. The average diameter of the smaller hairs in *O. Willisii* is 80 $\mu$  and in *O. crenulata* 70 $\mu$ , both examples coming within the range of the *O. paniculata* type. In no species of either *Olea* or *Notelaea* has such a wide difference been observed; in fact it can be said of recent species that the range in size is not considerable. Reference has already been made to the difficulty experienced in interpreting the structure of the hairs of *Oleinites*. Whilst they appear to have been built on the same general plan as those of the *O. europaea* and *O. paniculata* types, their greater variability both in size and number of rays, together with the apparently greater freedom of the ray-cells and the higher degree of cutinization of their walls, distinguishes them from the peltate hairs of recent species.

(c). *Epidermal Parenchyma*.—In the majority of recent Oleaceae the cells of the epidermal parenchyma have straight lateral walls. A few, however, such as *O. foveolata*, *O. vitiensis* and *O. montana*, agree with *Oleinites* in having epidermal cells with undulating lateral walls.

Solereider (loc. cit., p. 522) notes for leaves of the Oleaceae that “the outer walls of the epidermal cells are distinguished by considerable thickness”. This feature, shown well by *O. lanceolata* and *O. verrucosa*, where the wall may be as much as 26 $\mu$  thick, also characterizes *Oleinites*, more particularly *O. Willisii*, in which the upper cuticle is about 13 $\mu$  thick. Solereider continues with the remark that “the cuticle not uncommonly shows undulated striation”. Personally, I have observed clearly defined striations in the upper cuticles of such species as *Olea exasperata*, *O. lanceolata*, *Notelaea ligustrina* and *N. longifolia*. An interesting comparison is thus afforded with *Oleinites crenulata*, in which the upper cuticle is conspicuously striated, the striations following, more or less, the sinuous outlines of the cells themselves. The cuticle of the cells of the lower surface which cover the venules show longitudinal striations.

(d). *External Morphology*.—The leaves of the Oleaceae are simple, entire, petiolate and vary considerably in size within a species. This description applies equally well to the two fossil species, a wide size-range being apparent in both.

The prominence of the venation is another variable character. In *Olea cuspidata* and *O. exasperata*, for example, as in *Oleinites Willisii*, the midrib is the only vein clearly distinguishable on both sides of the leaf. Bentham (1869, p. 298) makes use of this character in his key to the Australian species of *Notelaea*, to distinguish *N. ligustrina* and *N. linearis* from the remaining species in which a reticulum is conspicuous. On the other hand, the prominent network of *Oleinites crenulata* is paralleled amongst the Oleas by the somewhat finer and less obvious reticulum of *O. paniculata*.

The retuse apex of *O. Willisii* is remarkably similar to that of *Osmanthus Badula*, although the slight narrowing towards the apex in that species contrasts with the usually broader tip of *O. Willisii*. This resemblance is only of minor importance, however, since retuse apices occur in widely divergent families.

The last morphological character that must be briefly mentioned is the thickened leaf-margin of *O. Willisii*. It is interesting to find the counterpart

of this in the thickened "nerve-like" margin of *Notelaea linearis* mentioned by Bentham (loc. cit., p. 300) and to see it prominently developed also in *Osmanthus Badula* (Plate viii, fig. 6) and *Olea exasperata*.

(e). *Geographical Distribution*.—The Oleineae is well represented in the recent floras of Australia, Polynesia and New Zealand. Five species of *Olea* have been recorded from this area, one, namely, *Olea paniculata*, being endemic to Australia. Several species of *Notelaea* also occur in the Australasian Region, five of which are Australian species. Without entering into greater details, therefore, it is clear that the present distribution of the Oleineae is consistent with the tentative suggestions put forward in this paper regarding the taxonomy of *Oleinites*.

#### CUTICULAR STRUCTURE OF SOME RECENT OLEINEAE.

This section has been prepared with the assistance of Miss S. Duigan, B.Sc., whose willing co-operation I acknowledge with much pleasure; I am further indebted to Miss Duigan for the drawings shown in Text-figures 1-4. Thanks are also due to Mr. A. W. Jessep, Director of National Herbarium of Victoria, for providing the specimens used in this study.

The cuticles were removed by the action of a warm 12% solution of sodium hypochlorite, after a previous boiling in water to soften the dried tissues.

#### 1. AVERAGE DIAMETER OF PELTATE HAIRS 100-180 $\mu$ .

##### *Olea europaea* Linn. Mediterranean Region.

*Lower Epidermis*.—Cells small, lateral walls thin, unpitted, slightly sinuous; cuticle thin, faintly striated. Stomata about 300 per sq. mm., absent from the parenchyma over the veins and immediately surrounding the hair bases; elliptical, averaging  $28 \times 21\mu$ , the long diameter ranging from  $26-33\mu$ . Large stomata average  $37 \times 19\mu$ , and range from  $37-41\mu$  long. Peltate hairs are extremely numerous, averaging 180 per sq. mm.; each shield is divided into about 24-30 cells which become free from one another towards the periphery; the average diameter is  $160\mu$ , and the scales overlap.

*Upper Epidermis*.—Cells small, lateral walls thin, straight and unpitted. Glands average 50 per sq. mm.

##### *Olea chrysophylla* Lam. Abyssinia.

*Lower Epidermis*.—Cells small, lateral walls thin, straight, unpitted. Stomata about 340 per sq. mm., evenly distributed, elliptical, averaging  $21 \times 15\mu$ , long axis  $18-26\mu$ . Large stomata not developed. Peltate hairs numerous, 160 per sq. mm.; shield about  $118\mu$  in diameter, composed of 24 rays which become free at the periphery.

*Upper Epidermis*.—Cells small, lateral walls moderately thick, straight, and unpitted; cuticle granular; peltate hairs average 46 per sq. mm.

##### *Olea cuspidata* Well. India.

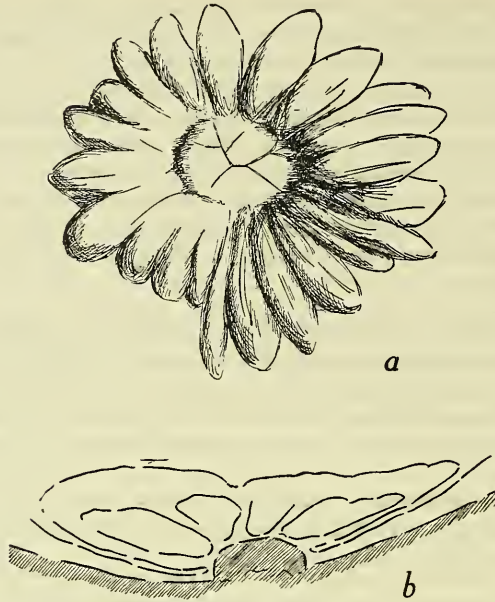
*Lower Epidermis*.—Cells small, lateral walls thin, unpitted, slightly sinuous. Stomata evenly distributed, approximately 330 per sq. mm.; elliptical, averaging  $23 \times 16\mu$ , with a range in length of  $18-26\mu$ . Large stomata not differentiated. Peltate hairs numerous, overlapping, approximately 160 per sq. mm.; shield divided into 24 rays, which become free near the periphery; average diameter  $124\mu$ .

*Upper Epidermis*.—Cells of medium size, lateral walls thin, sinuous, unpitted; those immediately adjacent to the stalks of the hairs larger, with straighter walls. Peltate hairs average 57 per sq. mm.

#### 2. AVERAGE DIAMETER OF PELTATE HAIRS 80-100 $\mu$ .

##### *Olea exasperata* Jacq. South Africa.

*Lower Epidermis*.—Cells of medium size, lateral walls straight, thick, unpitted; outer walls thick; cuticle granular. Stomata evenly distributed, approximately 200 per sq. mm.; broadly elliptical in shape, average size  $34 \times 26\mu$ , the long axis ranging from  $26-37\mu$ . Large stomata average  $53 \times 37\mu$ , and range in length from  $44-59\mu$ . Venules



Text-fig. 3.—(a). Peltate hair of *Oleinites crenulata* in surface view,  $\times 600$ . (b). Vertical section of lower cuticle of *Oleinites Willisii* showing peltate hair,  $\times 600$ .

are absent. Peltate hairs average 33 per sq. mm.; the shield is divided into 16 unequal rays; margin entire, sinuous; average diameter  $80\mu$ .

*Upper Epidermis*.—Cells of medium size, lateral walls thick, straight, and unpitted; cuticular striations conspicuous; glands sparse, averaging 8 per sq. mm.

*Olea glandulifera* Desf. India.

*Lower Epidermis*.—Cells small, lateral walls thin, straight, unpitted, those adjoining the bases of the hairs being larger. Veins conspicuous. Stomata approximately 370 per sq. mm., absent from the parenchyma covering veins and surrounding the hairs and large stomata. Elliptical in shape, averaging  $26 \times 20\mu$ , the long axis ranging from  $22-30\mu$ . Large stomata average  $38 \times 27\mu$  and range from  $36-44\mu$ . Peltate hairs numerous, approximately 85 per sq. mm.; shield more or less circular in shape, composed of  $16-20$  unequal rays; average diameter  $84\mu$ .

*Upper Epidermis*.—Cells large, lateral walls thin, slightly sinuous, pitted; cuticle granular, peltate hairs moderately numerous, approximately 45 per sq. mm.

*Olea paniculata* R.Br. Queensland.

*Lower Epidermis*.—Cells small, lateral walls thin, slightly sinuous, unpitted; cuticle thin and faintly striated. Stomata about 250 per sq. mm., unevenly distributed, absent from parenchyma covering the venules and around the glands; narrowly elliptical, with average diameters of  $25 \times 17\mu$ , and a range in length of  $22-30\mu$ . Large stomata average  $35 \times 23\mu$ , and range in length from  $33-41\mu$ . Peltate hairs about 33 per sq. mm. Scale more or less circular in outline, with an entire margin; divided into 16 cells; average diameter  $90\mu$ .

*Upper Epidermis*.—Cells of medium size, lateral walls thin, sinuous, and unpitted. Peltate hairs about 13 per sq. mm.

3. AVERAGE DIAMETER OF PELTATE GLANDS UNDER  $60\mu$ .

*Olea acuminata* Wall. India.

*Lower Epidermis*.—Cells small, lateral walls moderately thick, slightly sinuous, unpitted; two rows with straight walls arranged radially around each gland; cuticle faintly granular. Stomata very numerous, averaging 850 per sq. mm.; small, approxi-



mately circular, the average being  $19 \times 20\mu$ , and the range in length 15–26 $\mu$ . Large stomata very sparse, when present, restricted to parenchyma above the veins; elliptical, averaging  $32 \times 24\mu$ , with a range in length of 28–36 $\mu$ . Peltate glands infrequent, approximately 12 per sq. mm.; head oval, with an entire margin; divided into 8 cells, those on either side meeting at a median line; average diameter 35 $\mu$ .

*Upper Epidermis*.—Cells small, lateral walls moderately thick, slightly sinuous, and unpitted. Glands very sparsely developed, approximately 3 per sq. mm.

*Olea apetala* Vahl. New Zealand.

*Lower Epidermis*.—Cells small, lateral walls thick, slightly sinuous, unpitted. Cells radially arranged around the bases of the glands and the large stomata. Stomata absent from venules and vicinity of glands; approximately circular, averaging  $25 \times 23\mu$ , with a range of 22–27 $\mu$ . T-shaped thickening present at junction between guard cells. Large stomata, elliptical; average size  $35 \times 26\mu$ , range in length from 34–41 $\mu$ . Peltate glands about 11 per sq. mm., head approximately circular, divided into 8 irregular rays; average diameter 43 $\mu$ .

*Upper Epidermis*.—Cells moderately large, lateral walls thick, slightly sinuous, and pitted. Glands approximately 4 per sq. mm.

*Olea capensis* Linn. South Africa.

*Lower Epidermis*.—Cells of medium size, lateral walls thick, straight, unpitted. Stomata approximately 110 per sq. mm., absent from parenchyma covering veins and surrounding glands and large stomata; elliptical, averaging  $33 \times 22\mu$ ; range of the long axis 22–37 $\mu$ . Large stomata distinct, averaging  $52 \times 28\mu$ , long axis ranging from 38–59 $\mu$ . Peltate glands very sparsely developed, approximately 3 per sq. mm. The head is divided into 12 rays, and has a slightly wavy margin; the average diameter is 46 $\mu$ .

*Upper Epidermis*.—Cells medium, with thick, straight, unpitted walls. Glands very sparse, approximately 1 per sq. mm.

*Olea concolor* E. Mey. South Africa.

*Lower Epidermis*.—Cells small, lateral walls thick, straight, unpitted, outer wall thick, undulant. Stomata evenly distributed, approximately 130 per sq. mm., elliptical in shape, averaging  $39 \times 30\mu$ , with a range in length of 26–44 $\mu$ . Large stomata averaging  $60 \times 40\mu$ , with a range in length of 56–67 $\mu$ , particularly conspicuous near the midrib. Peltate glands approximately 33 per sq. mm.; head, 47 $\mu$  in diameter, divided into about 16 rays of slightly irregular length.

*Upper Epidermis*.—Cells large, lateral walls rather thin, straight, sparsely pitted. Glands approximately 13 per sq. mm.

*Olea Cunninghami* Hook. New Zealand.

*Lower Epidermis*.—Cells small, arranged radially in one row around the bases of the glands; lateral walls moderately thick, straight, unpitted. Stomata approximately 450 per sq. mm., absent from the veins and the vicinity of the glands; elliptical with flattened poles, average size  $26 \times 22\mu$ , with a range in length of 22–33 $\mu$ . Polar T-shaped thickening present. Peltate glands approximately 47 per sq. mm., heads oval, entire, each divided by exceedingly thin walls into 8 rays; average diameter 41 $\mu$ .

*Upper Epidermis*.—Cells small, lateral walls moderately thick, straight, pitted; cuticle irregularly reticulate. Glands approximately 35 per sq. mm.

*Olea dioica* Roxb. India.

*Lower Epidermis*.—Cells small, lateral walls thin, slightly sinuous, unpitted; cells bordering glands more or less radially arranged; cuticle granular. Stomata, absent from the immediate vicinity of glands and large stomata, approximately 330 per sq. mm. Elliptical to almost circular, average  $24 \times 20\mu$ , with the long axis ranging from 22–26 $\mu$ ; T-shaped thickening conspicuous. Large stomata average  $32 \times 26\mu$ , and have a long axis ranging from 30–33 $\mu$ . Peltate glands approximately 39 per sq. mm.; heads elliptical to circular, with even margins, each with 8 faintly defined rays; average diameter 25 $\mu$ .

*Upper Epidermis*.—Cells small, lateral walls thin, slightly sinuous, unpitted; cuticle granular; peltate glands average 12 per sq. mm.

*Olea foveolata* E. Mey. South Africa.

*Lower Epidermis*.—Cells medium, lateral walls thin, sinuous, unpitted. Cells bordering glands and large stomata radially arranged, with thicker, straighter walls; cuticle faintly granular. Stomata arranged in irregular lines; approximately 210 per sq. mm.; elliptical, averaging  $29 \times 23\mu$ , with a range in length of  $26\text{--}33\mu$ . Large stomata rare, sparsely present on midrib,  $37 \times 17\mu$ , with a range of the long axis of  $37\text{--}41\mu$ . Peltate glands very infrequent, approximately 2 per sq. mm.; heads oval, 16 celled, with an average diameter of  $42\mu$ . Short broad, thick-walled, sharply pointed hairs,  $95\mu$  in length, are sparsely developed.

*Upper Epidermis*.—Cells small, lateral walls thick, somewhat sinuous, pitted. Glands and hairs absent.

*Olea lanceolata* Hook. f. New Zealand.

*Lower Epidermis*.—Cells of medium size, arranged radially around the bases of the glands; lateral walls thick, straight, unpitted; outer wall thick. Cuticle finely striated. Stomata about 160 per sq. mm.; elliptical, averaging  $40 \times 27\mu$ , with the long axis ranging from  $26\text{--}48\mu$ . Large stomata not distinguishable. Peltate glands about 12 per sq. mm., occasionally forming small compact groups; head circular, divided into 16 cells; average diameter  $48\mu$ .

*Upper Epidermis*.—Cells small, lateral walls thick, straight, and unpitted; cuticle thick, undulated striation conspicuous. Glands very sparse, about 3 per sq. mm.

*Olea maritima* Wall. Malaya.

*Lower Epidermis*.—Cells of medium size, those around the glands and large stomata radially arranged and with straight walls, the remainder with thin, sinuous, unpitted lateral walls; cuticle granular to striated. Stomata approximately 290 per sq. mm.; absent from the parenchyma covering the veins and in the vicinity of the glands and large stomata; elliptical to circular, averaging  $24 \times 20\mu$ , long axis ranging from  $19\text{--}30\mu$ . Large stomata average  $33 \times 21\mu$ , and vary in length from  $30\text{--}37\mu$ . Peltate glands about 43 per sq. mm.; head roughly circular in outline, divided into 8 slightly unequal cells; average diameter  $27\mu$ .

*Upper Epidermis*.—Cells of medium size, lateral walls moderately thick, slightly sinuous, unpitted; cuticle faintly granular. Glands average 26 per sq. mm.

*Olea montana* Hook f. New Zealand.

*Lower Epidermis*.—Cells of medium size, slightly larger and thicker walled near the glands; lateral walls thin, slightly sinuous, unpitted; cuticle irregularly reticulate. Stomata about 240 per sq. mm., absent from parenchyma over the veins and in the immediate vicinity of glands and large stomata; elliptical, with flattened poles; average size  $30 \times 26\mu$ , range in length  $26\text{--}33\mu$ ; T-shaped thickening present. Large stomata average  $41 \times 27\mu$ ; length range  $37\text{--}52\mu$ . Peltate glands sparse, about 6 per sq. mm.; head oval to circular, divided into 12 cells; average diameter  $46\mu$ .

*Upper Epidermis*.—Cells large, lateral walls thin, sinuous, unpitted; cuticle granular to striated. Glands about 5 per sq. mm. Unicellular pointed hairs developed on the parenchyma over the veins.

*Olea myrtifolia* Wall. India.

*Lower Epidermis*.—Cells small, lateral walls thin, straight, unpitted; outer wall thin. Stomata approximately 570 per sq. mm., absent from parenchyma covering the veins; elliptical in shape, averaging  $23 \times 16\mu$ , long axis ranging from  $19\text{--}33\mu$ . Peltate glands approximately 8 per sq. mm., oval to circular, divided into 8 rays, margin entire; average diameter  $29\mu$ .

*Upper Epidermis*.—Cells small, lateral walls thick, straight and pitted; cuticle faintly striated. Glands very sparse—about 1 per sq. mm.



*Olea polygama* Wight. Ceylon.

*Lower Epidermis*.—Cells moderately large, with thin, somewhat sinuous, unpitted walls; cuticle striated. Stomata approximately 250 per sq. mm.; elliptical, averaging  $26 \times 21\mu$ , the long axis ranging from 22–30 $\mu$ ; T-shaped polar thickening present. Large stomata prominent, occurring principally over the veins; average size  $41 \times 29\mu$ , the long axis ranging from 37–48 $\mu$ . Peltate glands sparsely developed, approximately 7 per sq. mm.; heads circular, often somewhat flattened; usually divided into 8 component cells; margin entire; average diameter 46 $\mu$ .

*Upper Epidermis*.—Cells small, lateral walls moderately thick, straight, unpitted; cuticle faintly granular. Glands sparse, 2 per sq. mm.

*Olea robusta* Sweet. India.

*Lower Epidermis*.—Cells small, arranged radially around the bases of the glands; lateral walls moderately thick, straight, unpitted; cuticle faintly striated. Stomata approximately 420 per sq. mm., wanting over the venules and near the glands; broadly elliptical, averaging  $25 \times 20\mu$ , with a range in length of 19–30 $\mu$ . Large stomata average  $34 \times 27\mu$  and range in length from 33–37 $\mu$ . Peltate glands sparse, about 9 per sq. mm.; head approximately circular, divided into 8 slightly unequal cells; average diameter 35 $\mu$ .

*Upper Epidermis*.—Cells moderately large, lateral walls thin, straight, and pitted. Glands very sparse, about 2 per sq. mm.

*Olea sandwicensis* A. Gray. Hawaii.

*Lower Epidermis*.—Cells small, radially arranged around the glands; lateral walls thick, straight, unpitted; outer wall thick. Stomata approximately 280 per sq. mm., absent from parenchyma over veins and immediately surrounding glands; elliptical, averaging  $26 \times 20\mu$ , the long axis ranging from 19–30 $\mu$ . T-shaped thickening faintly indicated. Large stomata  $36 \times 27\mu$ , range in length 33–41 $\mu$ . Peltate glands about 34 per sq. mm.; head roughly circular, divided into 8 rays; average diameter 56 $\mu$ .

*Upper Epidermis*.—Cells small, lateral walls thick, slightly sinuous, unpitted. Glands sparse, about 8 per sq. mm.

*Olea verrucosa* Link. South Africa.

*Lower Epidermis*.—Cells small, lateral walls thick, straight, unpitted; outer wall very thick. Stomata about 220 per sq. mm.; elliptical, average size  $35 \times 28\mu$ , with a range in length of 26–50 $\mu$ . Glands approximately 17 per sq. mm.; heads missing in the material available for examination.

*Upper Epidermis*.—Cells of medium size, lateral walls thick, straight, unpitted; outer wall thick—26 $\mu$ . Glands 5 per sq. mm.

*Olea vitiensis* Seem. Tonga I.

*Lower Epidermis*.—Cells of medium size, lateral walls thin, sinuous, unpitted. Stomata about 130 per sq. mm., unevenly distributed, absent from midrib; elliptical to somewhat circular, average size  $27 \times 20\mu$ , with a range in length of 26–33 $\mu$ . Large stomata not differentiated. Peltate glands about 32 per sq. mm.; head roughly circular, divided into 12 cells; average diameter 48 $\mu$ .

*Upper Epidermis*.—Cells of medium size; lateral walls moderately thick, slightly sinuous, unpitted. Glands very sparse, about 1 per sq. mm.

*Notelaea ligustrina* Vent. Tasmania.

*Lower Epidermis*.—Cells of medium size, arranged radially around glands and large stomata; lateral walls thin, straight, unpitted; cuticle striated. Stomata approximately 220 per sq. mm., absent over the veins and the immediate vicinity of glands and large stomata; elliptical, average size  $32 \times 21\mu$ , the long axis ranging from 26–37 $\mu$ . Large stomata average  $43 \times 24\mu$ , with a range in length of 41–44 $\mu$ . Peltate glands infrequent, approximately 15 per sq. mm.; the head oval with an entire margin, irregularly divided into from 8–14 cells; average diameter 53 $\mu$ .

*Upper Epidermis*.—Cells moderately large, lateral walls thick, straight, unpitted; cuticular striations faint and irregular. Glands average 3 per sq. mm.



*Notelaea linearis* Benth. New South Wales.

*Lower Epidermis*.—Cells medium, radially arranged around the bases of the glands; lateral walls rather thin, straight, unpitted. Stomata average 250 per sq. mm., absent from the parenchyma above the veins and in the immediate vicinity of the glands and large stomata; broadly elliptical, averaging  $31 \times 26\mu$ , with a range of  $30\text{--}33\mu$ . Large stomata average  $39 \times 29\mu$ , with a range in length of  $37\text{--}41\mu$ . Peltate glands about 15 per sq. mm., head approximately circular with an entire margin, divided into 12 irregular rays; average diameter  $38\mu$ .

*Upper Epidermis*.—Cells moderately large, with thick, straight, unpitted walls; cuticle faintly granular. Glands very few, averaging 3 per sq. mm.

*Notelaea longifolia* Vent. Victoria.

*Lower Epidermis*.—Cells small, radially arranged around the bases of the glands; lateral walls thin, straight, unpitted; cuticle striated. Stomata approximately 810 per sq. mm., almost circular, averaging  $22 \times 21\mu$ , and ranging in length from  $17\text{--}24\mu$ ; T-shaped thickening present. Large stomata average  $27 \times 25\mu$ , and range in length from  $27\text{--}29\mu$ . Peltate glands approximately 22 per sq. mm.; head elliptical to circular, divided into 8 unequal cells; average diameter  $35\mu$ .

*Upper Epidermis*.—Cells of medium size, lateral walls thick, straight, unpitted; cuticle striated. Glands approximately 14 per sq. mm.

*Notelaea ovata* R.Br. New South Wales.

*Lower Epidermis*.—Cells small, those around the hair bases and large stomata radially arranged; lateral walls thick, straight, unpitted; outer wall thick. Stomata average 450 per sq. mm., absent from parenchyma over venules and immediate vicinity of glands; approximately circular, average size  $23 \times 22\mu$ , with a range in length of  $19\text{--}27\mu$ ; T-shaped thickening conspicuous. Large stomata average  $34 \times 22\mu$ , and range in length from  $31\text{--}36\mu$ . Peltate glands about 16 per sq. mm.; the head elliptical to circular, divided into 8 unequal cells; average diameter  $35\mu$ . Slightly curved, unicellular hairs numerous.

*Upper Epidermis*.—Cells of medium size, lateral walls thick, straight and unpitted, outer walls thick. Glands very sparse, averaging 4 per sq. mm. Unicellular, slightly curved, hairs present.

*Notelaea punctata* R.Br. Queensland.

*Lower Epidermis*.—Cells small, somewhat radially arranged around the bases of the glands; lateral walls thin, straight, unpitted; outer wall thick. Stomata about 510 per sq. mm., absent from parenchyma over the veins and around the glands. Elliptical to circular, from  $22\text{--}30\mu$  long, averaging  $26 \times 22\mu$ . Large stomata average  $31 \times 20\mu$ , and range from  $29\text{--}34\mu$ . Peltate glands about 22 per sq. mm.; head, roughly circular with an even margin, divided into 8 cells; average diameter  $29\mu$ .

*Upper Epidermis*.—Cells of medium size, lateral walls thin, slightly sinuous, unpitted; cuticle granular. Glands about 6 per sq. mm.

*Linociera Wightii* C. B. Clarke. India.

*Lower Epidermis*.—Cells small, those surrounding the glands radially arranged; lateral walls moderately thick, straight, unpitted; cuticle faintly granular. Stomata approximately 320 per sq. mm., absent above venules and in the vicinity of the glands; broadly elliptical, with an average size of  $24 \times 19\mu$  and a range in the long axis of  $19\text{--}26\mu$ . Large stomata not developed. Peltate glands sparse, about 8 per sq. mm.; head oval, entire, composed of 8 cells; average diameter  $39\mu$ .

*Upper Epidermis*.—Cells small, lateral walls thick, straight and unpitted. Cuticle faintly granular. Glands sparse, about 3 per sq. mm.

*Osmanthus Badula* Hutch. New Caledonia.

*Lower Epidermis*.—Cells moderately large, radially arranged around the glands; cuticle granular. Stomata average 170 per sq. mm., widely spaced; absent from the

parenchyma over the veins and around the glands; elliptical, averaging  $35 \times 28\mu$ , with a range in length of  $30-37\mu$ . Large stomata range from  $44-67\mu$  in length and have an average size of  $51 \times 33\mu$ . Peltate glands very sparse, about 5 per sq. mm.; heads roughly circular, with an entire margin, divided into 8 irregular rays; average diameter is  $40\mu$ . Unicellular, thick-walled, sharply pointed hairs, about  $80\mu$  long, are scattered evenly over the surface.

*Upper Epidermis.*—Cells moderately large, with thick, straight, unpitted walls; cuticle granular. Glands very few, about 3 per sq. mm. Unicellular hairs sparse.

#### FOSSIL POLLEN OF OLEACOID TYPE.

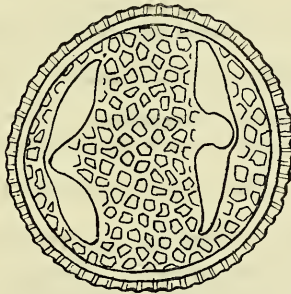
Fossil pollen grains that show a close resemblance to grains of some recent members of the Oleineae occur in preparations made from ligneous clay at Maryvale, Victoria. Unfortunately this oleacoid type is not restricted to the family Oleaceae and cannot, therefore, be used as direct evidence in favour of the suggested oleaceous affinity of the fossil *Oleinites*. However, it is of interest and some significance to find such fossil pollen grains in beds deposited during the same period as those containing *Oleinites Willisii*. For this reason, therefore, it is recorded here as a new southern sporomorpha under the name *Tricolporites sphaerica*.

*TRICOLPORITES SPHAERICA*, n. sp. Plate ix, figs. 14, 15. Text-fig. 4.

Grains tricolporate, prolate-sphaeroidal to spherical, in equatorial view  $25.5-29\mu$  long and  $25.5-29\mu$  broad; furrows and pores conspicuous. Exine finely reticulate about  $2\mu$  thick, membrane over furrows smooth.

*Locality.*—State Electricity Commission Bore 155, 552 feet, Maryvale, Victoria.

*Horizon.*—Tertiary ? Oligocene-Miocene.



Text-fig. 4.—*Tricolporites sphaerica*,  $\times 1,400$ .

Acetolysed pollen grains of some Australian species of Oleaceae have been compared with *Tricolporites sphaerica*. The latter are clearly distinct from grains of *Jasminum*, which apart from being larger, possess a distinctive beaded reticulum not unlike that of *Ligustrum* (Erdtman, 1943, Fig. 280). On the other hand, *Tricolporites sphaerica* agrees rather closely as regards size, shape and sculpture with pollen grains of such species of *Olea* as *O. paniculata* (Queensland), *O. Cunninghamsii* (New Zealand), *O. montana* (New Zealand) and *O. europaea*. In the living types, however, the furrows appear to be less sharply defined than in the fossil grains.

Pollen grains of *Notelaea*, e.g., *N. ligustrina* and *N. microcarpa*, although essentially similar to *Tricolporites sphaerica*, differ in being considerably smaller.

#### DIAGNOSES OF NEW GENUS AND SPECIES.

##### Genus OLEINITES, n. gen.

Leaves simple, petiolate, dorsiventral. Outer wall of upper epidermal cells thick, firm and highly cutinized; peltate hairs present on both surfaces; stomata of unequal size.

## OLEINITES WILLISII, n. sp.

Leaves oblanceolate, tapering to a short petiole, 1-9 cm. long; apex retuse; margin thick, entire; with the exception of the midrib, quite veinless on both surfaces.

*Horizon*.—Tertiary ? Oligocene-Miocene.

*Locality*.—Open cut, Yallourn, Victoria.

Named in honour of Mr. J. H. Willis, B.Sc., of the National Herbarium of Victoria, who has shown considerable interest in the identification of this fossil type.

## OLEINITES CRENULATA, n. sp.

Leaves broadly elliptic-lanceolate, narrowing at the base; apex obtuse to subacute, apparently retuse; margin crenulate, not conspicuously thickened; rugulose on both sides, more conspicuously so above, upper cuticle undulately striated.

*Horizon*.—Tertiary ? Oligocene-Miocene.

*Locality*.—Brown coal deposits, Moorlands, South Australia.

## SUMMARY.

A new type, *Oleinities*, n. gen., is recorded from Tertiary brown coal deposits in south-eastern Australia.

Two species are distinguished.

Cuticular features which suggest affinity with the family Oleaceae are discussed.

Fossil pollen grains of oleacoid type are described under the sporomorpha *Tricolporites sphaerica*.

Cuticles of some recent species of *Olea*, *Notelaea*, *Osmanthus* and *Linociera* are briefly described.

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## EXPLANATION OF PLATES VIII-X.

All the figures are from untouched negatives. C before a specimen number refers to the Cookson collection. Duplicate specimens will be deposited in the Department of Geology, British Museum.

## Plate viii.

Fig. 1.—Sample of brown coal with thickly bedded cuticles of *Oleinities Willisii* from just beneath the overburden—open cut, Yallourn, Victoria. 5/6 nat. size (Nat. Mus. Vict., No. 14527).

Figs. 2, 3.—*O. Willisii*. Leaf cuticles viewed from above, showing range in size (C.203).

Fig. 4.—*O. Willisii*. Cuticle viewed from below, showing wide midrib and thickened margin,  $\times 2$  (C.200a).

Fig. 5.—*O. Willisii*. Distal region of upper cuticle, viewed from within, showing retuse apex and thick margin,  $\times 2$  (C.200b).

Fig. 6.—*Osmanthus Badula*. Apex of leaf from below,  $\times 2$ .

Fig. 7.—*O. Willisii*. Portion of an upper cuticle, viewed from within, to show elevations in positions of peltate hairs,  $\times 10$ .

## Plate ix.

Fig. 8.—*O. Willisii*. Upper cuticle,  $\times 110$  (C.s. 52).

Fig. 9.—*O. Willisii*. Lower cuticle,  $\times 78$  (C.s. 53).

Fig. 10.—*O. Willisii*. Lower cuticle,  $\times 110$  (C.s. 53).

Fig. 11.—*O. Willisii*. Large stoma in region of midrib,  $\times 150$  (C.s. 54).

Fig. 12.—*Olea concolor*. Lower cuticle showing variations in size of stomata,  $\times 150$ .

Fig. 13.—*Olea foveolata*. Lower cuticle showing linear arrangement of stomata,  $\times 150$ .

Figs. 14, 15.—*Tricolporites sphaerica*. Pollen grain focused for furrows and sculpture of exine, respectively,  $\times 1,400$  (C.s. 55).



## Plate x.

Fig. 16.—*Oleinites crenulata*. Portion of upper cuticle. Moorlands, South Australia. Nat. size (C.201).

Fig. 17.—*O. crenulata*. Apex of same specimen,  $\times 4$ .

Figs. 18–21.—*O. crenulata*. Upper cuticles showing external features,  $\times 2$  (C.202).

Fig. 22.—*Olea paniculata*. Upper surface of portion of a dried leaf to show fine, reticulate venation,  $\times 2$ .

Fig. 23.—*Oleinites crenulata*. Upper cuticle showing three peltate hairs and sinuate outlines of epidermal cells,  $\times 150$  (C.s. 48).

Fig. 24.—*O. crenulata*. Portion of upper cuticle showing peltate hair and undulating striations,  $\times 250$  (C.s. 49).

Fig. 25.—*O. crenulata*. Lower cuticle with large and small stomata,  $\times 150$  (C.s. 50).

Fig. 26.—*O. crenulata*. Lower cuticle showing deeply sinuate outlines of epidermal cells,  $\times 150$  (C.s. 51).

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